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PROJECT ADMINISTRATION DATA SHEET

[x] ORIGINAL [ ] REVISION NO. _____

Project No. A-3445 GTRI/~~GIT~~ DATE 1-5-83

Project Director: Dr. Zenon Redkevitch ~~School~~/Lab EMSL

Sponsor: Garden State Paper Company, Inc.

Type Agreement: Standard Research Project Agreement

Award Period: From 1-1-83 To ~~4-30-83~~ 5/31/83 (Performance) 8/15/83 (Reports)

Sponsor Amount: Total Estimated: $ 49,204 Funded: $ 49,204

Cost Sharing Amount: $ NA 7/31/83 Cost Sharing No: _____

Title: Feasibility Study for Removal of Sticky Contaminants from Recycled Newsprint

ADMINISTRATIVE DATA

OCA Contact Frank Huff

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Vice President, Research
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Defense Priority Rating: _____

Military Security Classification: _____

(or) Company/Industrial Proprietary: see below

RESTRICTIONS

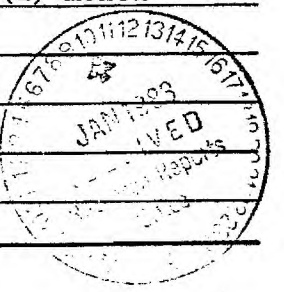
See Attached - Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval – Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with None

COMMENTS:

Article 9 prohibits publication of results of research sooner than one (1) month following submission of final report covering Phase I.



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SPONSORED PROJECT TERMINATION SHEET

Date September 27,1983

Project Title: "Feasibility Study for Removal of Sticky Contaminants from Recycled Newsprint'

Project No: A-3445

Project Director: Dr. Zenon Redkevitch

Sponsor: Garden State Paper Company

Effective Termination Date: 7/31/83

Clearance of Accounting Charges: 8/15/83

Grant/Contract Closeout Actions Remaining:

- [X] Final Invoice ~~and Closing Documents~~
- [ ] Final Fiscal Report
- [X] Final Report of Inventions
- [ ] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
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A-3445

ENGINEERING EXPERIMENT STATION
Georgia Institute of Technology
A Unit of the University System of Georgia
Atlanta, Georgia 30332

February 7, 1983

Dr. Frank W. Lorey
Vice President, Research
Garden State Paper Company, Inc.
Park 80 Plaza East
Saddlebrook, N.J. 07662

Subject: Project A-3445 - Feasibility Study for Removal of Sticky Contaminants from Recycled Newsprint

Dear Dr. Lorey:

My recent visit to your operations in Saddlebrook was most helpful. Much of the information learned there will be appropriately utilized while working on our project. We have almost completed preliminary work and shall be starting on actual testing soon.

Status to date:

1. Identified several suppliers of adhesives, labels, tapes, etc. Having some difficulty locating non-repulpable material as newspaper companies we have contacted indicate that they try to use repulpable material.

2. Studied techniques used to analyze for chemical content of adhesives. This information will be applied when evaluating the effectiveness of scavenger materials. We do not plan to carry out elaborate analytical work but only will apply those procedures that determine the quantity of stickies transferred from a pulp slurry to a scavenger material.

3. Established a two part test program. Part One should determine actual stage at which stickies form. Part Two will test whether (and how effectively) stickies migrate to scavengers.

4. Prepared 12 fibers to be tested as scavengers.

(Continued)

5. Designed three possible testing units for scavenger evaluation. Will choose one and start fabrication week of February 7, 1983.

6. Pulp slurries will be prepared using equipment on loan from Garden State.

The above is a short summary of work to date. Should you desire more detail at this time we shall be pleased to supply it.

Best regards.

Sincerely,

Zenon Redkevitch
Director, Program Development
Bioengineering Division
Energy and Materials Sciences Laboratory

ZR:JK

cc: A. Turbak
H. Spauschus
F. Huff

FINAL REPORT: PROJECT A-3445

FEASIBILITY STUDY FOR REMOVAL OF STICKY CONTAMINANTS FROM RECYCLED NEWSPRINT

by

Zenon Redkevitch and A. R. Colcord

Georgia Institute of Technology

September, 1983

performed for:

Garden State Paper Company, Inc.
P. O. Box C-32333
Richmond, VA 23293

GEORGIA INSTITUTE OF TECHNOLOGY
A Unit of the University System of Georgia
Engineering Experiment Station
Atlanta, Georgia 30332

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1983

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Summary

This report describes the research program aimed at demonstrating the feasibility of removing sticky contaminants from recycled newspaper slurry by a scavenger material which would preferentially capture the contaminant but not the paper fibers.

The test program used hydro-pulped old newspapers in 100 gm batches to form a slurry. The stickies were produced by adding adhesive coated newsprint to the batch while being pulped. After pulping the hydro-pulped newspaper was diluted to a 10 liter volume for testing. One, two or three batches of pulped newspaper were used to give a 1, 2, or 3% slurry concentration with 0.5 gm of stickies per 100 gm batch of newspaper.

The major results follow:

1. The feasibility of removing significant quantities of stickies were demonstrated.
2. The most effective scavenger was polyethylene tube spiral wrapped with cotton twine and coated with adhesive.
3. Higher relative velocity between slurry and scavenger resulted in greater % removal of stickies.
4. Significant amounts of stickies were removed in 15 to 20 minutes.
5. Generally higher slurry concentration resulted in higher sticky removal percent.

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INTRODUCTION

Considerable problems are encountered in the recycling of newspaper, as a direct result of the presence of adhesive contaminants in the waste newsprint. The problems may properly be divided into two main areas. Firstly, those mills producing newsprint paper suffer from residual adhesive particles in the paper that may cause breaks at various stages of the paper machine and at the rewinder. Secondly, the printing of newspapers suffers from breaks at the presses caused by the sticking of paper to paper, resulting in downtime.

Generally, undesirable adhesives are for the most part dispersed chemically during repulping of the waste newspaper. A very small percentage, however, remain as undispersed small particles affectionately called "stickies". A major portion of these may be removed by employing well known screening/centrifuging procedures. Nevertheless, the last remaining, very small portion of the stickies contributes to the operational problem. Although this final portion could be removed by additional screening devices such techniques are extremely costly.

Garden State Paper Company has taken part in several research programs in an effort to find a reasonably economic procedure to remove these residual sticky contaminants. This project is one such effort.

Since like materials have an affinity for each other, it was postulated that a substance could be found which would attract and capture the stickies present in a pulp slurry but would not attract the cellulose fibers.

The objective of this research, therefore, was to determine the feasibility of removing substantial quantities of sticky contaminants from a pulp slurry by the selective attraction of the stickies to potential scavenger materials.

EXPERIMENTAL PROGRAM

The project was generally divided into the following categories.

1. Stickies
   - Identify
   - Obtain samples of adhesives
   - Prepare stickies in laboratory
   - Evaluate variables of sticky formation

It is accepted that the stickies are a direct result of the presence of non-repulpable adhesives used for splicing. Our plan was to identify such adhesives, obtain raw samples from suppliers and use these in the controlled preparation of stickies in the laboratory.

2. Scavenger materials
   - Identify
   - Preliminary screening

The premise is that some material exists that selectively captures stickies, and not fiber, from a pulp slurry. A broad range of potential scavengers are to be subjected to preliminary screening.

3. Experimental equipment
   - Design
   - Fabricate
   - Test

Criteria for the experimental design of laboratory test equipment was to approximate conditions found in the paper mill.

4. Experimental procedures
   - Screen out scavengers
   - Run qualitative tests
   - Determine quantitative effects

The experiments were to follow a two part program. First, preliminary screening of scavenger materials would identify the best choices, if any, for stickies removal. Second, quantitative experiments would be run to determine efficiency of stickies removal at several controlled parameters.

1. Stickies

The problem of stickies in newsprint manufacture has been known for some time. Generally, the problem is brought about when recycled newsprint makes up all or a portion of the finish used in the production of paper. Recycled newsprint usually contains various types of adhesives that were used to splice the newspaper during the production process. Splices may be made at the rewinder in the paper mill and also when introducing a new roll at the printing press. The adhesives used for splices are usually pressure sensitive types and may be applied as liquids, tabs, tapes, etc. These may or may not be repulpable. The repulpable adhesives do not present a problem. It is the non-repulpable adhesives that go through the hydro-pulper, deinking, dispersant, washing, and screening stages and end up as little sticky balls in the finished paper.

There are many suppliers of these adhesives. For preliminary testing samples were obtained from:

H. B. Fuller Co.
4044 adhesive

B. F. Goodrich Co.
R888T adhesive
SC342 adhesive

New England Newspaper Supply Co.
R528XX adhesive
Aquabond adhesive
Press Formula Red adhesive
Nitto #509A tape

The 3M Company
A465 tape

Samples of newspapers at least 30 days old were obtained from The Atlanta Newspapers Inc.

2. Scavenger Materials

The School of Textile Engineering provided various filaments and spun yarn for initial screening as potential scavenger materials. The choice for scavengers covered a broad range of characteristics. The idea was to find a material that would match the properties of the stickies in the slurry. Since the adhesives used are usually the pressure sensitive types it was anticipated that the residual properties would be derived from at least one of the components in the original adhesives.

Pressure sensitive adhesives are usually rubber-based. These adhesives may contain a wide variety of component materials, such as elastomers, resins or tackifiers, fillers, and plasticizers.

Elastomers are natural or synthetic polymers which exhibit high extensibility and quick, forceful recovery. Examples are: natural rubber, styrene-butadiene copolymer, acrylonitrile - butadiene copolymer, silicone rubber, and butyl rubber.

Tackifiers are exemplified by different types and classes of natural and synthetic resins. These include rosin and rosin derivatives, polymerized terpenes, petroleum hydrocarbon resins, and thermoplastic and thermosetting phenolic resins.

Fillers are materials such as carbon black, zinc oxide, clays, calcium silicate and barium sulfate. Plasticizers include stearic acid, zinc laurate, mineral oil, and lanolin.

Based on the components of adhesives it was felt that a successful scavenger material would match the characteristics of elastomers and tackifiers, or the products obtained when these materials are subjected to the repulping process.

The initial choice for scavengers included the following:

A - Poly thread 800 D
B - Cotton
C - Nomex, black
D - Wool
E - Nylon 40/13 - 1/22 bright
F - Polypropylene - Herculon
G - Nomex - Dupont
H - Saran - Vectra
I - Polyester, dacron - Dupont
J - Rayon, viscose
K - Fiberglas
L - Teflon
M - Stabilized carbon fiber precursor
N - Final carbon fiber
O - 100% Dacron
P - Taslan Herculon yarn
Q - Teflon yarn
R - Herculon 2000
S - Wool blend

After preliminary screening, additional scavengers were prepared. The preparation took into consideration the fact that the stickies will stick to each other, and so increase in size, but tend to repel fiber. Consequently, some materials were coated with the adhesive which was used to produce the stickies. These were identified as follows:

T - Yarn coated with New England adhesive R528XX
U - Cotton string - coated with New England adhesive R528XX
V - Polyethylene tube coated with New England adhesive R528XX
W - Flat aluminum plate - coated with New England adhesive R528XX

3. Experimental Equipment

The design and construction of the test equipment was such as to ensure contact between the stickies and the candidate scavenger materials. This same equipment would later be used to develop data on the effects of various parameters on the selected scavenger material. Design configurations that were considered were as follows:

(a) Valley beater type
(b) Glass oval with stirrer
(c) Tank with baffled stirrer
(d) Tank with pump recircling line

The first three were discarded during the design review stage for reasons of cost or technical problems associated in determining exposure to scavengers to stickies. Design (d), the tank with pump and recirculating line was decided as the most promising approach. The initial construction utilized a large (30 gal) glat bottom tank to hold the slurry. It was thought that it would be practical to circulate a small volume of slurry with this equipment. This was not the case. Because of the flat bottom, stagnant areas were observed at the tank perimeter and the volume of the system larger than practical (approximately 5 gals). The system was modified by constructing a small round bottom tank which reduced the volume to 2 gals and eliminated any dead spots. With the equipment ready, preliminary test was the next step. Figure 1 shows the constructed equipment.

During the construction of the testing equipment, slurries containing sticky material were prepared using procedures and equipment supplies by Garden State. It was noticed that some of the stickies produced seemed quite large. In an attempt to reduce the size of the stickies the slurry was fed through a laboratory colloidal mill. Since it was anticipated that the mill would also reduce the fiber size, the mill was adjusted to maximize opening to minimize the fiber damage. Observation of the slurry being processed through the colloidal mill surprisingly showed, not smaller stickies but apparently fewer stickies. While the slurry was being removed, a ball of stickies approximately 1/2" dia. suddenly appeared. The action of the colloid mill caused the stickies to agglomerate. The obvious next test was to pump a slurry containing stickies through constructed test system. The results were the same as with the colloidal mill. The stickies agglomerated and came out as a large ball. The test system as designed obviously would not be suitable for testing scavenger materials.

The next design consisted of a way of moving the scavenger materials through the slurry rather than the slurry through or past the scavenger materials. A small metal frame was constructed and the scavenger materials fastened to it. The frame was then mounted in a small laboratory stirrer motor so that the frame became a stirrer. Thus the scavenger material was moved through the slurry. It was noticed that within a few revolutions slurry was rotating as a mass so that there was no relative motion between the

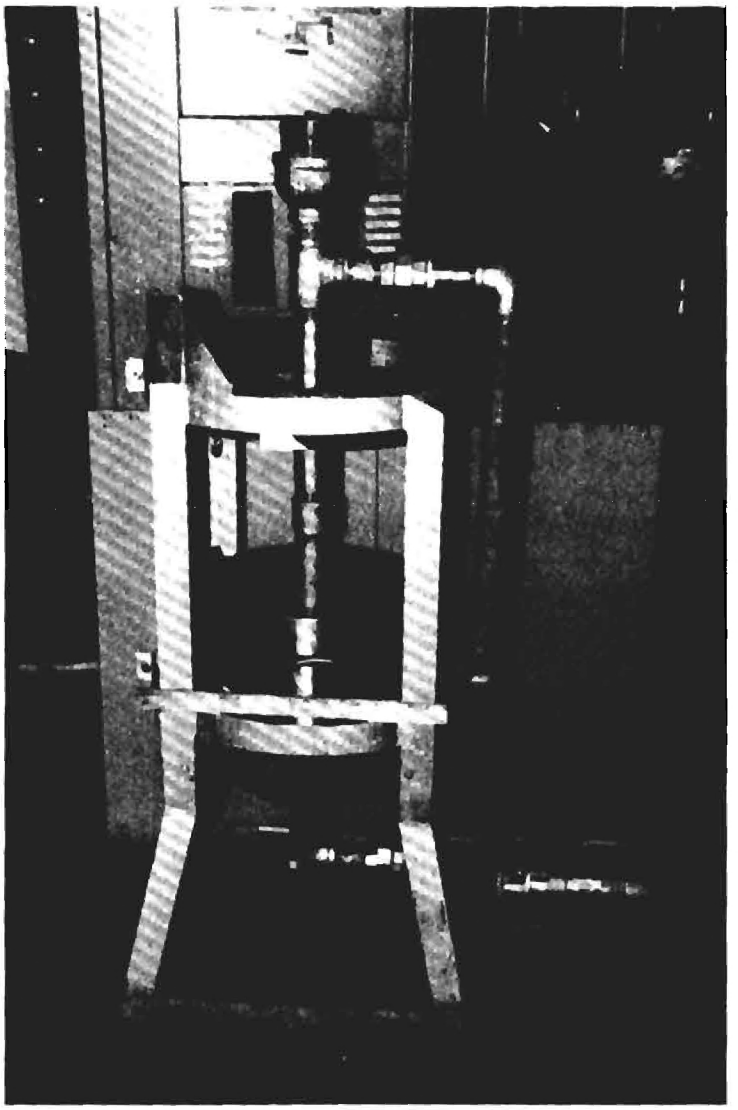


Figure 1. Recirculating Test System

slurry and the scavenger material. Therefore, by using the reversing switch on the motor control the stirrer could be periodically reversed. The system was automated by adding a timer which controlled the reversing of the stirrer. This system shown in Figure 2 was used for screening and was labelled System A. For quantitative tests a heavy duty stirrer was constructed. This was System B and is shown in Figure 3. It consisted of a bench drill press modified to utilize a reversible variable speed power supply with a standard fractional horsepower three phase motor.

Several frame designs were used. These were as shown in the following Figures:

Figure 4 - Frame A - Initial three rod frame. The materials were either wrapped around the frame using a continuous strand of individual strands were attached to the ends of the frame as illustrated in the figure.

Figure 5 - Frame B - A five rod configuration with short string tied to each rod in the form of a "butterfly".

Figure 6 - Frame C - Five rod configuration. A low density polyethylene tube is fastened to each rod.

Figure 7 - Frame D - Nine rod configuration. The same as C except nine rods instead of five rods.

Figure 8 - Frame E - With string lacing as shown.

Figure 9 - Frame F - Seven rod configuration with polyethylene tubes attached without string lacing. Permits testing a five and nine tubes configuration with one test.

Figure 9 - Frame G - Seven tube configuration with string lacing as shown.

Figure 10 - Frame H - Nine tube configuration. Five tubes spiral wound with cotton string and four tubes plain. Permitted simultaneous evaluation of spiral wound tubes and plain tubes.

Figure 11 - Frame I - Flat plates of metal, plastic or fabric. The plates can be adjusted to any angle.

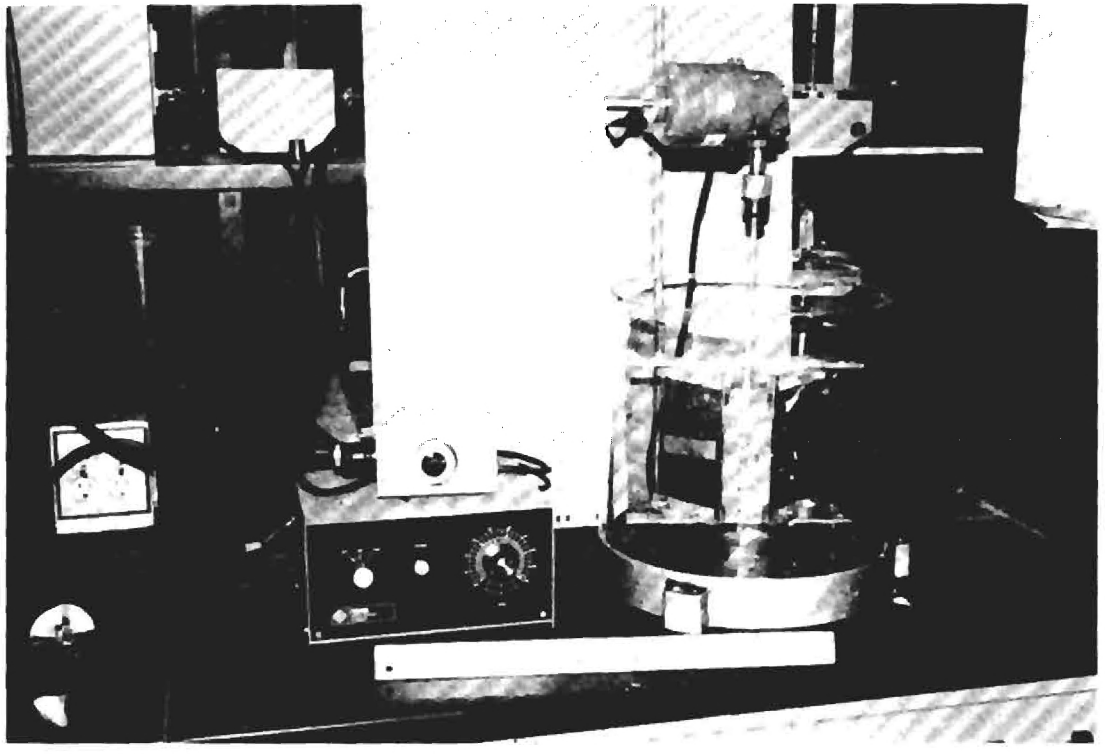


Figure 2. Screening System A

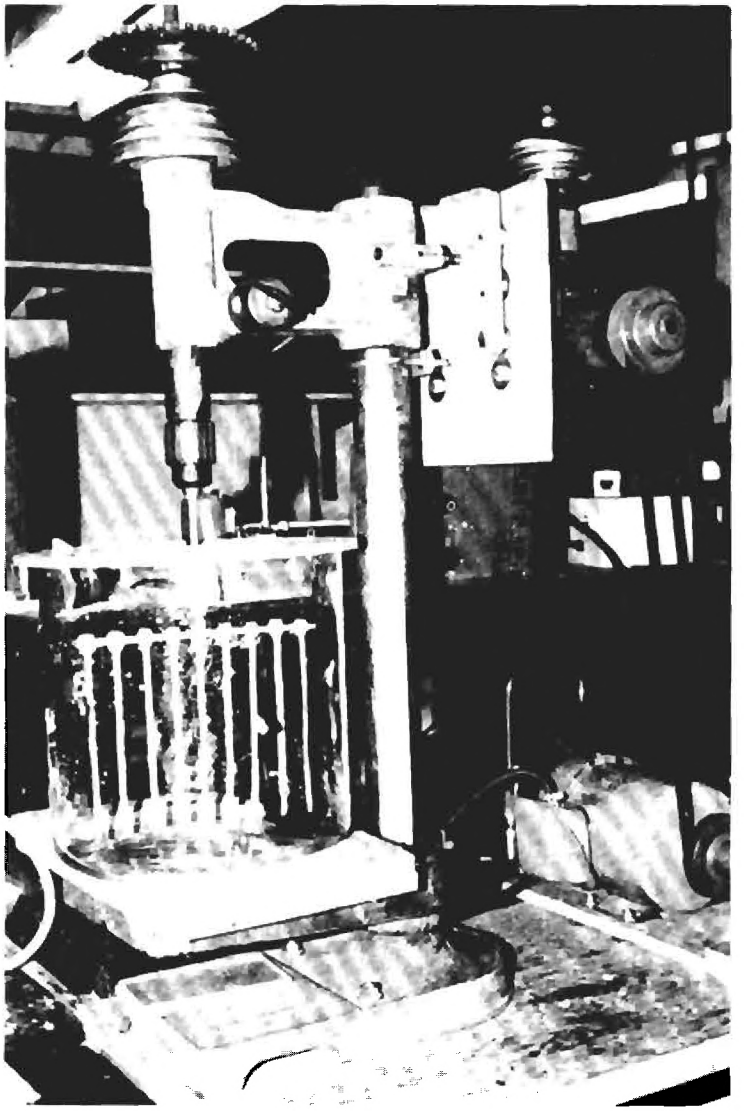


Figure 3. Screening System B

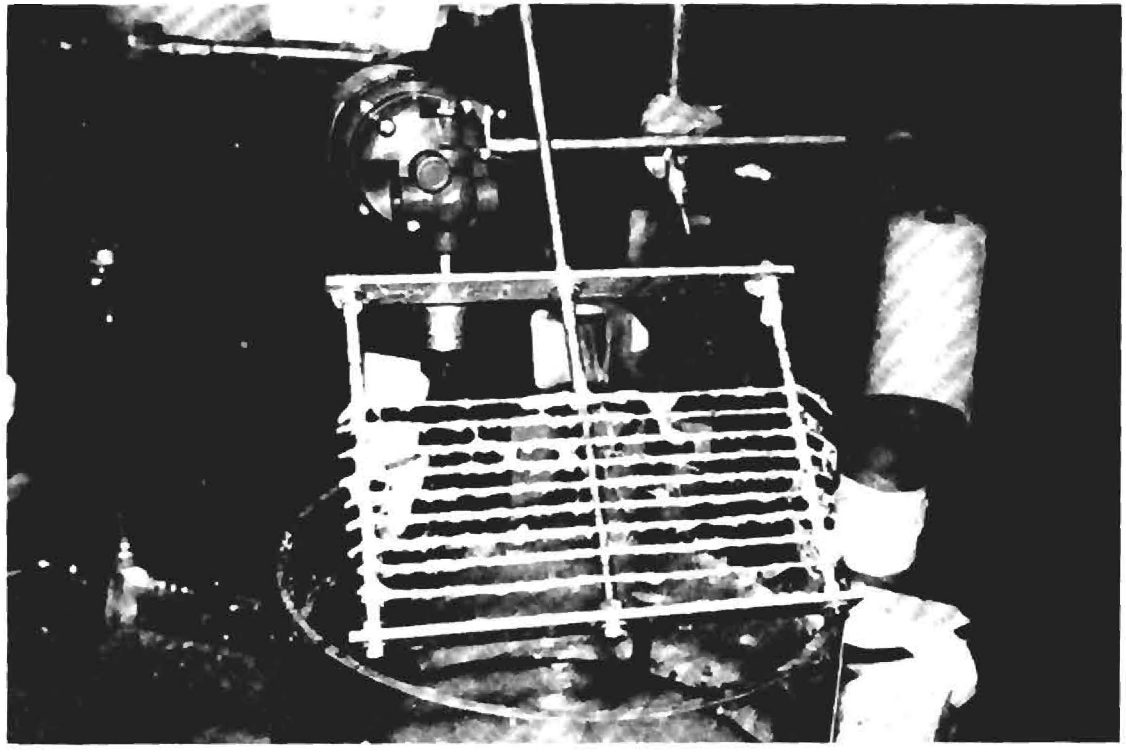


Figure 4. Frame A

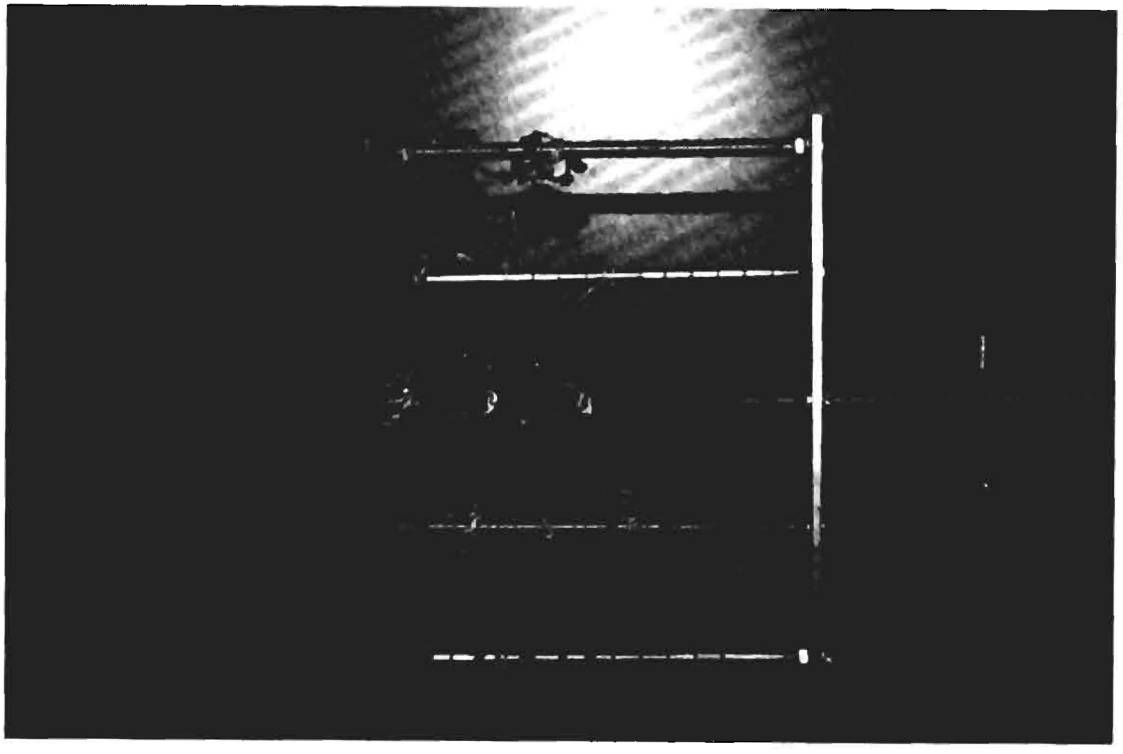


Figure 5. Frame B

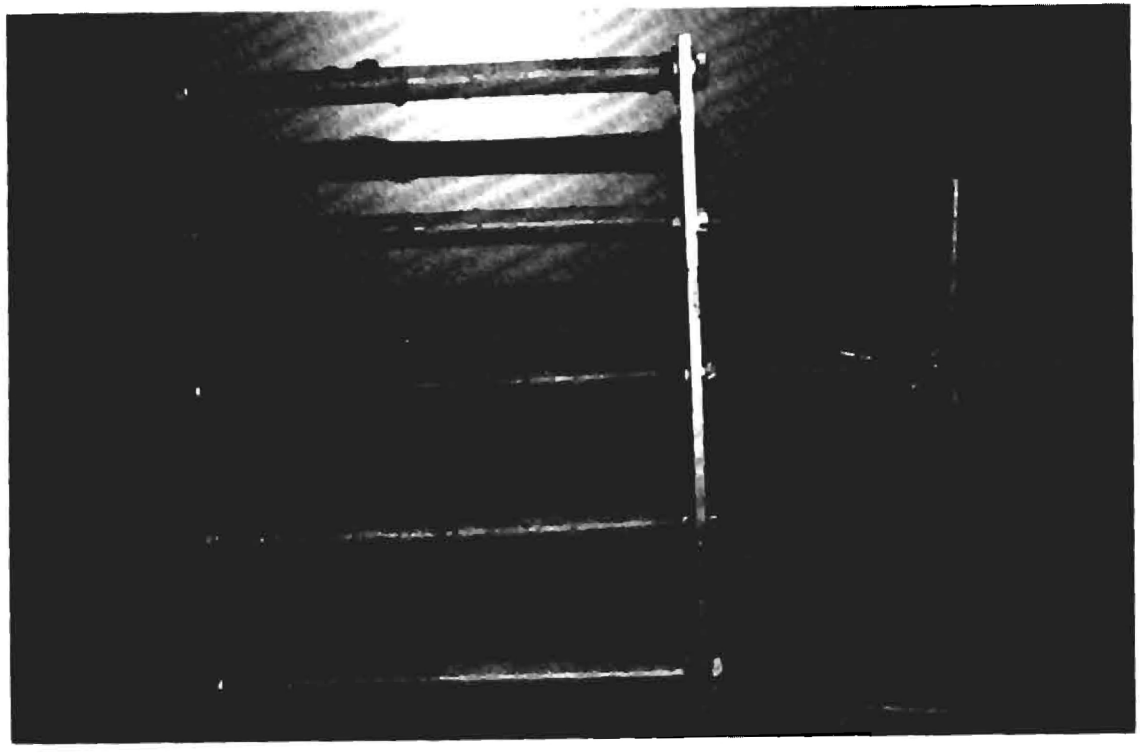


Figure 6. Frame C

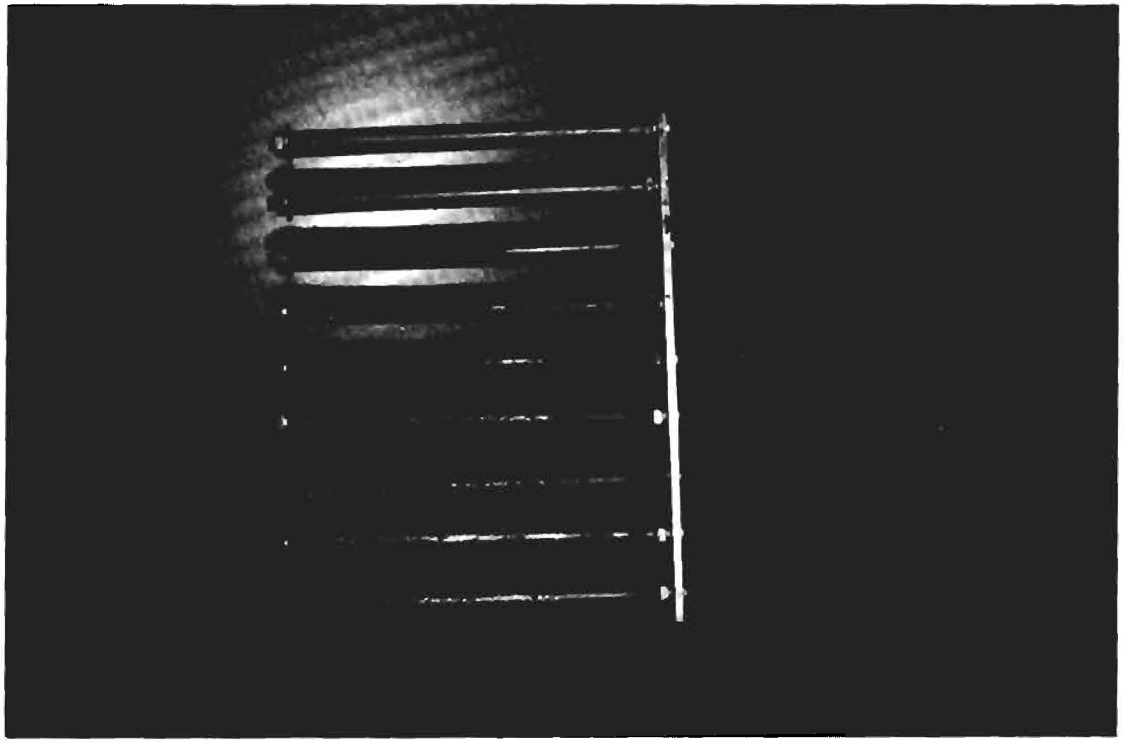


Figure 7. Frame D

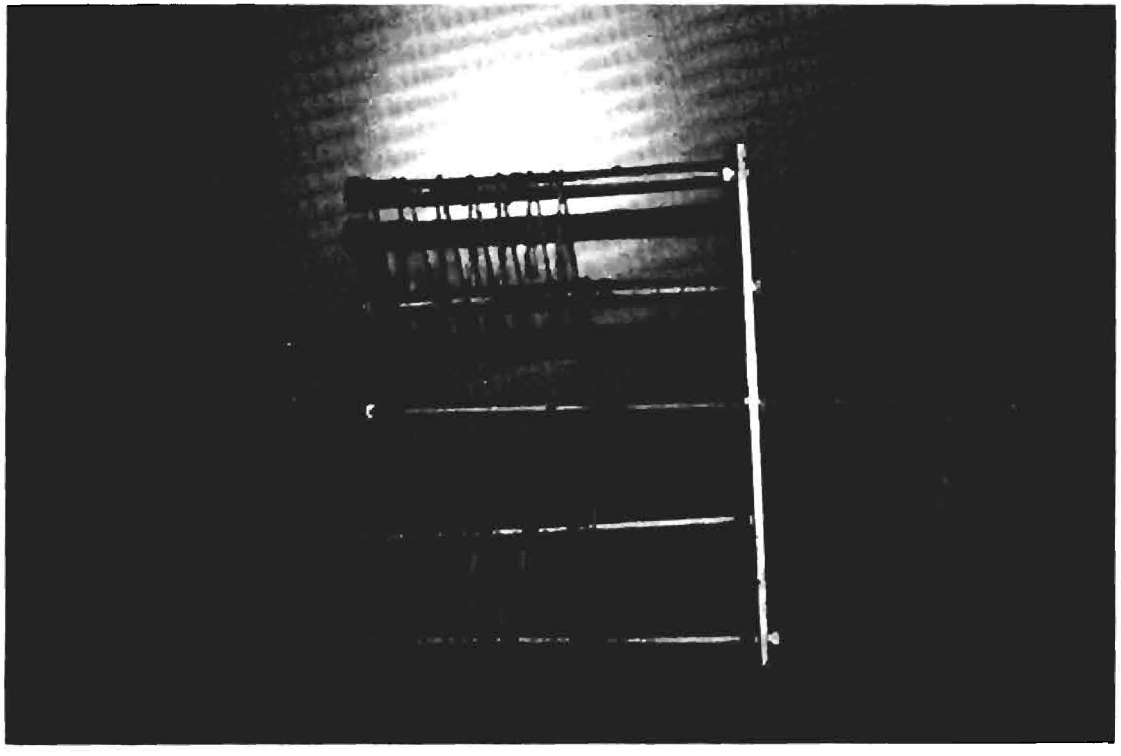


Figure 8. Frame E

Figure 9. Frame F and Frame G

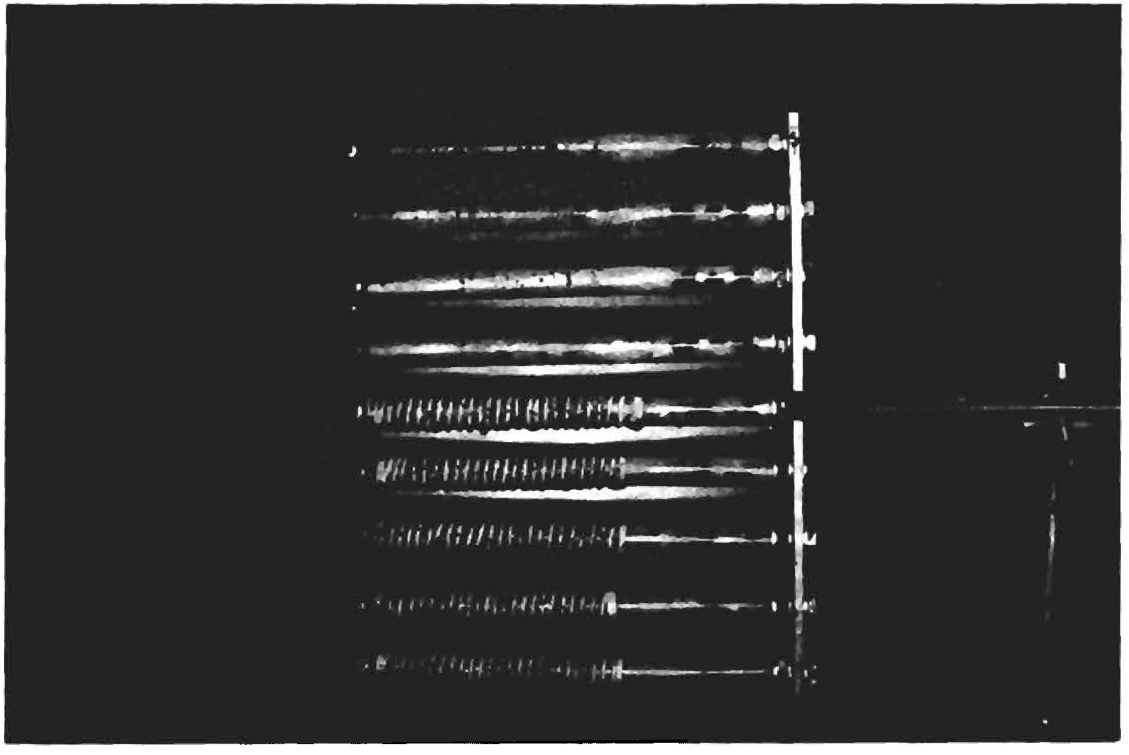


Figure 10. Frame H

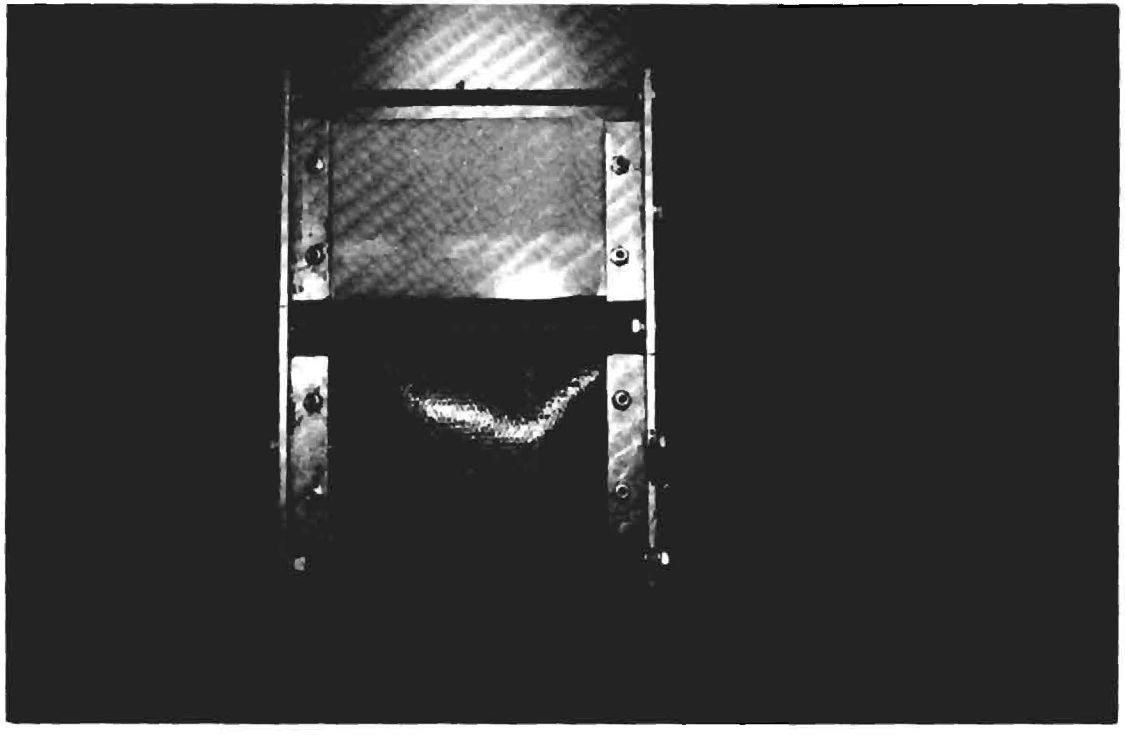


Figure 11. Frame I

4. Experimental Procedures

General Preparation Methods For Pulp Slurries

The general method for preparation of slurries was as used and recommended by Garden State Paper Company. In addition, Garden State also supplied the laboratory equipment for pulp preparation and the dispersent to be used for deinking, etc.

Method A: Pulp Slurry

1. Pour 1800 ml of water at 90^{o}F into pulper
2. Add 100 ml of G.S.P. chemicals
3. Add 100 gms of waste newspaper cut to 1" x 1-1/2", and soak for two minutes
4. Start pulper at slow speed. Run for five minutes.
5. Stop pulper, change belt to fast speed pulley and run for twenty minutes
6. Pour slurry on to 60 mesh screen and rinse thoroughly with water to wash pulp
7. Collect drained pulp and save for future use.

Method B: Pulp - Stickies Slurry

1. Follow Steps 1 and 2 of Method A
2. At Step 3 of Method A add known quantity of adhesive. If necessary adjust waste newspaper to that total paper is 100 gms.

Method C: Adhesive Addition - Tabs/Tapes

1. Remove adhesive from backing
2. Weigh required amount into pulper - Method B.

Method D: Adhesive Addition - Liquid

1. Apply liquid adhesive to unprinted newsprint paper using a 6 mil draw down wet film applicator
2. Place a sheet of unprinted paper on top of the wet film to form a sandwich.
3. Cut exact size segments of sandwich - weigh
4. Cut same size setments from uncoated paper - weigh
5. Determine weight of adhesive coat by difference
6. Correct pulp content in slurry for paper added with adhesive.

Check on Stickies Preparation

Various parameters of stickies preparation were evaluated to determine the effect these have on sticky size, dispersion, etc. The repulper was run using Methods A, B, C and/or D as appropriate. The following materials were used.

Run 1 - Water, waste newspaper
Run 2 - Water, waste newspaper, adhesive
Run 3 - Water, waste newspaper, adhesive, dispersant
Run 4 - Water, adhesive
Run 5 - Water, adhesive, dispersant
Run 6 - Water, waste newspaper, adhesive, dispersant
Run 7 - Water, unprinted newspaper, adhesive, dispersant

All runs in which adhesive was introduced were repeated for each adhesive from suppliers.

Preliminary Scavenger Tests

Each of the scavengers, A through S, were tested as follows:

1. Each scavenger was mounted in Frame A which was then installed in Test System A. Slurry batches were prepared as described by Methods B and D. Weight of adhesive added to each batch was 2 grams. For each scavenger test, three batches of slurries were poured into the test vessel and water was added to make up a total volume of 10 liters. System A was operated at 3 to 6 revolutions per reversal. Total time was 90 minutes.

Scavenger T and U were tested as follows:

1. Using Frame A and the procedure described above.
2. Same as 1. using Frame B.

Scavenger V and W were tested as follows:

1. Using Frame C, Frame D, Frame E, Frame F, Frame G and Frame H and the procedure described above, Scavenger W was tested using Frame I and the procedure described above.

Quantitative Program and Experiments

The purpose of phase tests was to determine the effect of such parameters as scavenger configuration, velocity of impingment of slurry into scavenger, and consistency of pulp and concentration of stickies on the efficiency of stickies removal by scavenger.

Screening Experiments

To determine the effects of rod configuration, two screening experiments were made. In the first test the stirrer was assembled so that one side had a five rod spacing and the other side had a nine rod spacing (assume that the whole stirrer was equally spaced). Low density polyethylene tubing 1/2" O.D. was dipped in adhesive, dried over night and mounted on each rod. The outer 2 or 3 tubes were connected by a lacing of cotton cord which was coated with adhesive. See Figure 9.
Consistancy was 3% and the adhesive content was 1.53 gms. The pulp was made up of three batches made of 100 gm of newspaper and approximately .5 gm of adhesive slurried according to Methods B and D previously described. The three batches were combined in the test container and water was added to get 10 liters of slurry.

Using System B, the slurry was agitated with the stirrer for 30 minutes each at speeds of 60 rpm, 100 rpm, and 175 rpm. The final weight and initial weight of the tubes were used to determine the weight of stickies removed from the slurry. The second screening test was a repeat of test 1 with the exception that each of the polyethylene tubes was wound with the cotton cord and then dipped in the adhesive. The tubes were weighed before and after exposure to the slurry. In addition, to determine the amount of ink picked up by the adhesive during the pulping operation, the slurry was screened by hand and the remaining stickies collected. Thus, by determining the weight of adhesive initially added to the slurry and the weight of adhesive plus ink in the slurry, the ratio of adhesive to adhesive plus ink was easily calculated to be 1:1.30. This ratio was used to determine the amount of adhesives removed in the form of stickies. A third screen test was performed to determine the effect of a coating on the perimeter of the test vessel. The procedure was the same as the two previous tests except that a piece of flexible plastic was coated with adhesive and attached to the inside perimeter of the test vessel. The piece could not be weighed so that a sample of the slurry was taken after the test and the amount of stickies determined in the sample. The total remaining in the slurry was estimated and the amount removed calculated by difference.

Quantitative Experiment

Based on the results of the screening test shown in Table 1 Frame H was selected for the test program. This configuration allowed the comparison of plain coated tubes with tubes spiral wound with cotton string and coated with adhesive. The test was designed to determine the effects of stirring speed and consistancy on the removal of sticky contaminants from repulped newspaper slurry. The parameters investigated were 60 and 165 rpm stirring speeds each at 1, 2 and 3% consistency.

The next set of tests were designed to determine the effect of time and slurry consistency at the higher stirring velocity on the removal of sticky contaminants. The test was conducted at 1%, 2% and 3% consistency at a stirring speed of 165 rpm. The tubes were numbered 1 thru 9. The tubes 1-5 were spiral wound with cord and tubes 6-9 were plain. The tubes were dipped in an adhesive solution made of 2 parts adhesive to 1 part naptha. The tubes were dried overnight and installed on the stirrer for testing. The slurry was made with 3%, 2% and 1% newspaper with a corresponding amount of 1.50, 1.00 or .5 gms of adhesive. The testing procedure was to oscillate the stirrer for 15 minutes. Then the tubes were removed, weighed and reinstalled. The test was then run an additional 30 minutes for a total 45 minutes. The tubes were again weighed, reinstalled and run an additional 60 minutes for a total of 105 minutes. After the final run the tubes were weighed and then placed in a hood and dried overnight with circulating ambient air. The tubes were then weighed and the total amount of adhesive removed calculated. Using a comparison of the final weight determined immediately after the test and the weight after drying overnight a correction factor was obtained so that an amount of stickies removed after 15 minutes and 45 minutes could be calculated.

RESULTS

1. Check on Sticky Preparation

Stickies in the form of small balls were formed only when a mixture of water, waste newspaper (printed or unprinted), and adhesive were combined. The dispersant seemed to have no effect on sticky size or formation. It was important, however, for paper to be present as this apparently introduced a shearing action on the adhesive. When no paper was present the

TABLE I

Results from Screening Tests*

Test No.	Conditions		Adhesive Pick Up	
			gm	%
ST-1	Vertical Tube Configuration with Lacing between Tubes	(A) 9 Tubes	1.48	96.7
		(B) 5 Tubes	0.69	45.4
ST-2	Vertical Tube Configuration with Tubes Spiral Wound with Cotton String	(A) 9 Tubes	1.57	105
		(B) 6 Tubes	0.74	49.3
ST-3	Circumferential Surface		0.89	59.1

*Test Conditions

3% Slurry
1.5 gm Adhesive
30 Min. at 60, 100 and 175 rpm

the adhesive simply retained its original shape. The thickness of the drawn down coating, the amount of adhesive placed in the repulper, and the waste newspaper all had an effect on the final stickies character. Thus, Methods B and D were followed precisely.

2. Preliminary Scavenger Tests

The results of the preliminary scavenger test are shown below:

Scavenger	Frame	Comments
A	A	Slight pick up
B	A	None
C	A	None
D	A	None
E	A	None
F	A	None
G	A	None
H	A	None
I	A	Slight pick
J	A	None
K	A	None
L	A	None
M	A	None
N	A	None
O	A	None
P	A	None
Q	A	None
R	A	None
S	A	None
T	A, C	Substantial pick up
U	A, C	Substantial pick up
V	C	Substantial pick up
W	I	Equipment failed

3. Preliminary Screening Tests

The results of the preliminary screening test are shown in Table I. The results indicated that the nine tube configuration with spiral wound cord and coated with adhesive (Frame 10) gave the maximum removal of stickies from the slurry. Therefore, that configuration was used for subsequent quantitative tests.

4. Quantitative Tests

The quantitative tests were designed to determine the effects for stirring velocity, slurry consistency and test time on the removal of stickies from pulp slurry.

The results of the first series of experiments, designed to demonstrate the effects of stirring velocity and slurry concentrataion are shown in Table II. Plots of this data (Figures 12, 13, 14 and 15) show the following:

1. % stickies removed increased with increased stirring velocity.
2. Spiral wound coated tubes removed significantly higher % of stickies than plain coated tubes.
3. The higher consistency, the higher % stickies removal.

The second series of experiments were designed to show the effects of stirring time and consistency on sticky removal. The results of these experiments are shown in Table III and plotted in Figures 16, 17 and 18.

The results from this data is as follows:

1. A significant % of stickies is removed in a 15 to 30 minute stirring time.
2. The spiral wound tubes have a much higher % removal than the plain tubes.

TABLE II

Amount of Stickies Removed VS
Stirring Velocity at Different Slurry Concentrations

Stirring Velocity (RPM)	Slurry Concentration											
	1%				2%				3%			
	9 Tubes Plain		9 Tubes Spiral Wound		9 Tubes Plain		9 Tubes Spiral Wound		9 Tubes Plain		9 Tubes Spiral Wound	
	(gm)	(%)	(gm)	(%)	(gm)	(%)	(gm)	(%)	(gm)	(%)	(gm)	(%)
60 (V_1)	0.02	4	0.05	11	0.06	6	0.13	13	0.14	10	0.33	23
165 (V_2)	0.05	11	0.11	24	0.18	18	0.47	46	0.27	19	0.91	64

Figure 12 Percent Stickies Removed by

Nine Plain Tubes VS Stirring Velocity

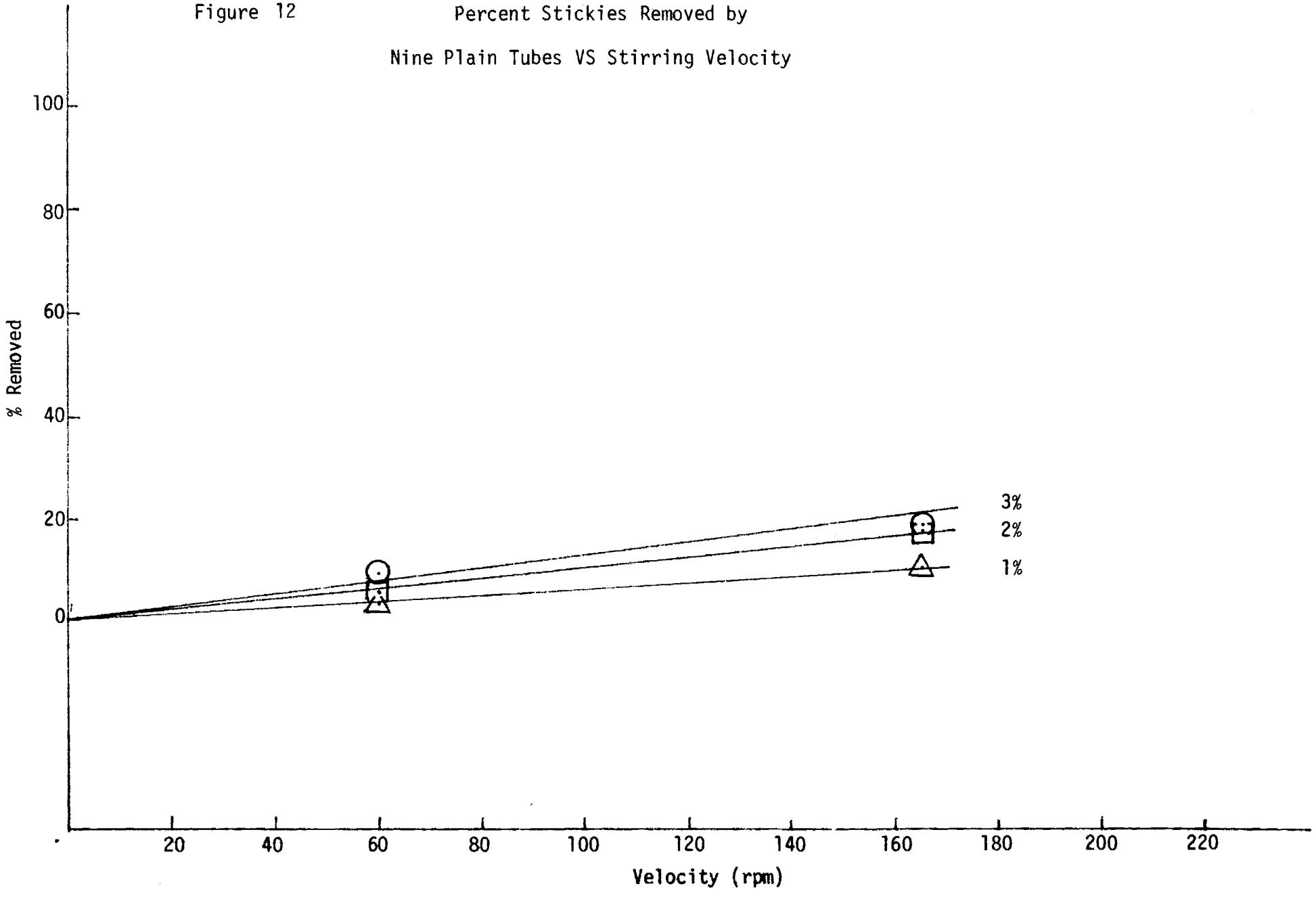


Figure 13 Percent Stickies Removed by
Nine Spiral Wound Tubes VS Stirring Velocity

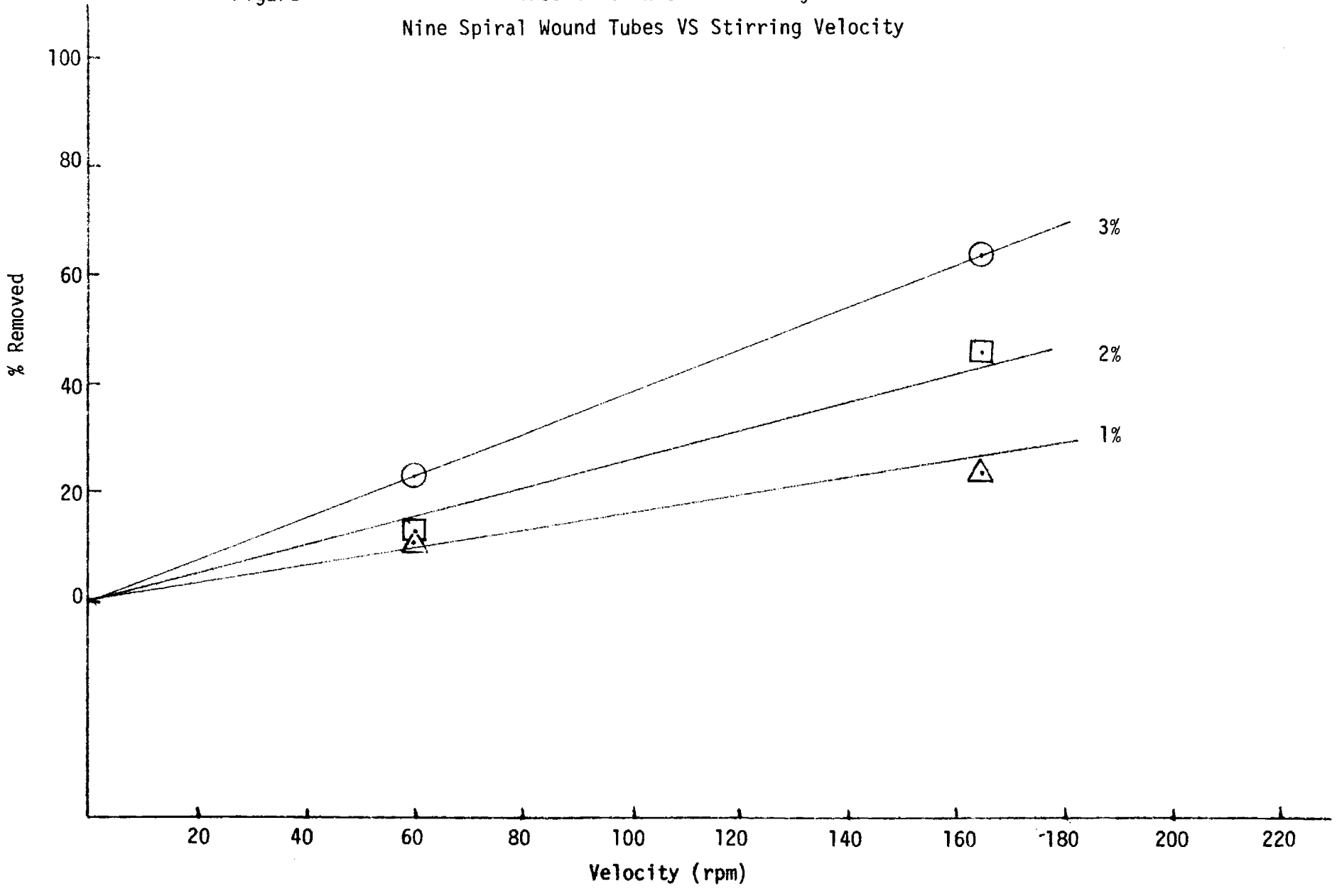


Figure 14 Percent Stickies Removed by Nine Plain Tubes VS. Slurry Concentration at 60 and 165 rpm Stirring Velocities

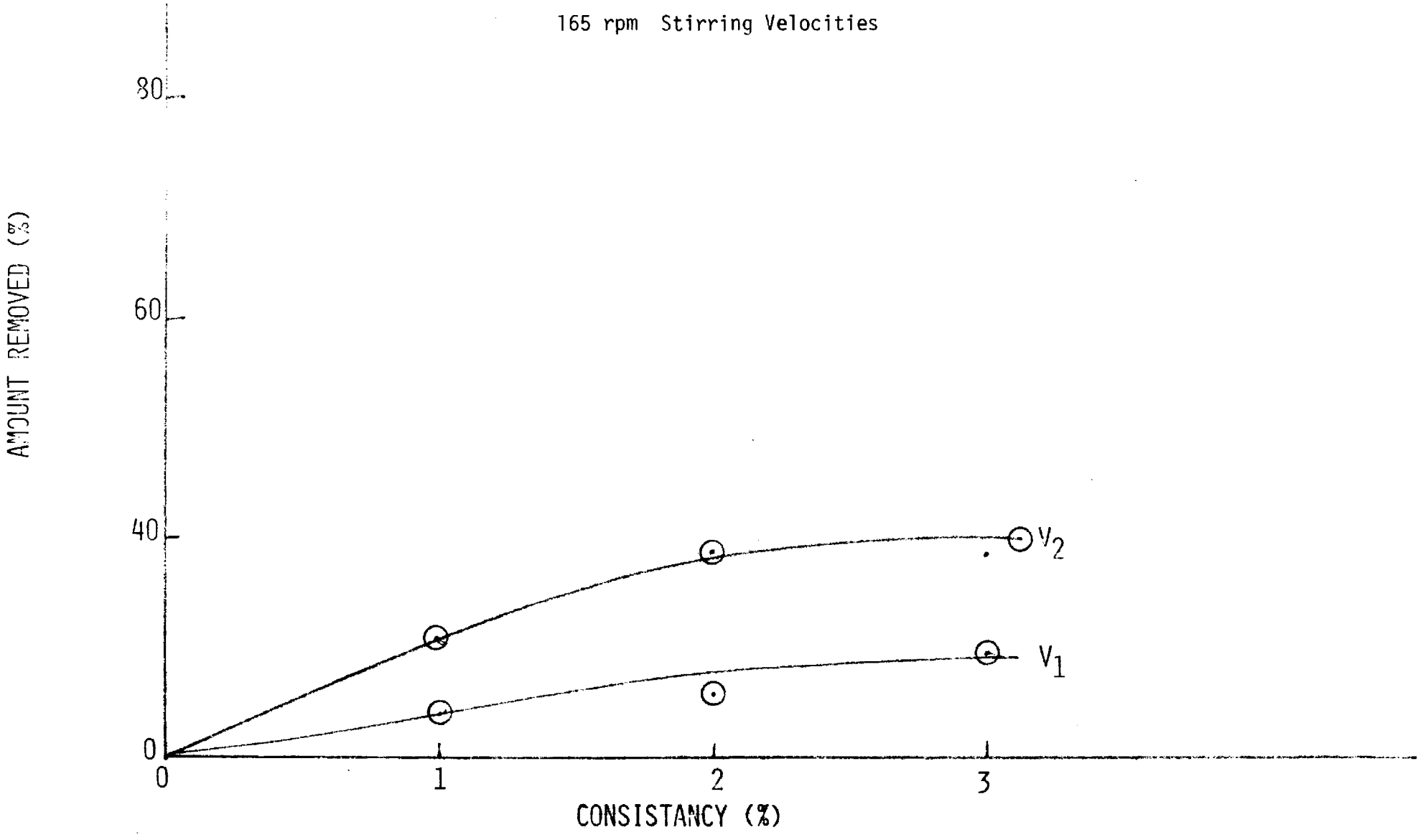


Figure 15 Percent Stickies Removed by Nine Spiral Wound Tubes VS Slurry Concentration at 60 and 165 rpm Stirring Velocities

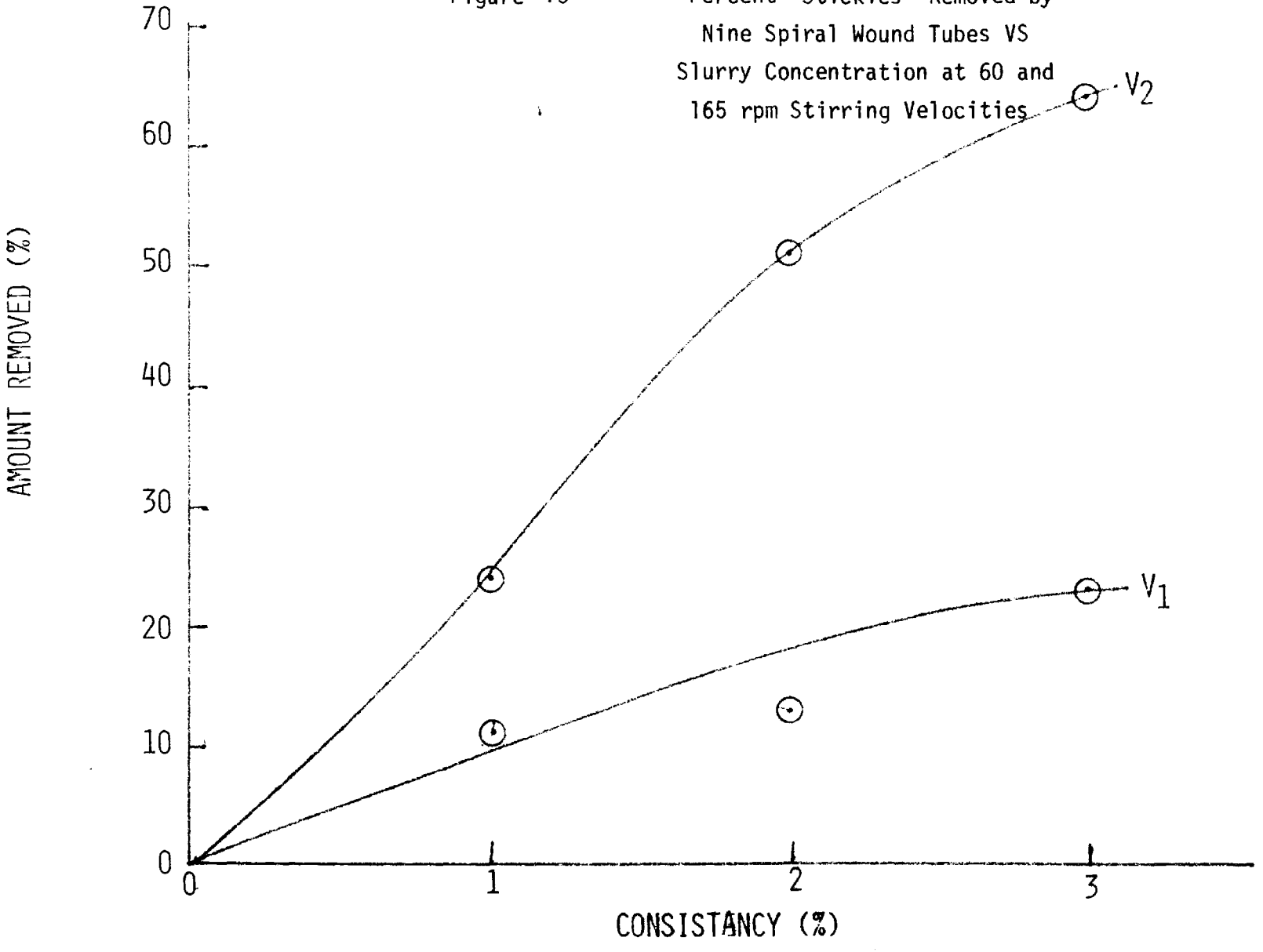


Figure 16 Percent of Stickies Removed VS
Time for 1%, 2% and 3% Slurry Concentrations
and Constant Stirring Velocity

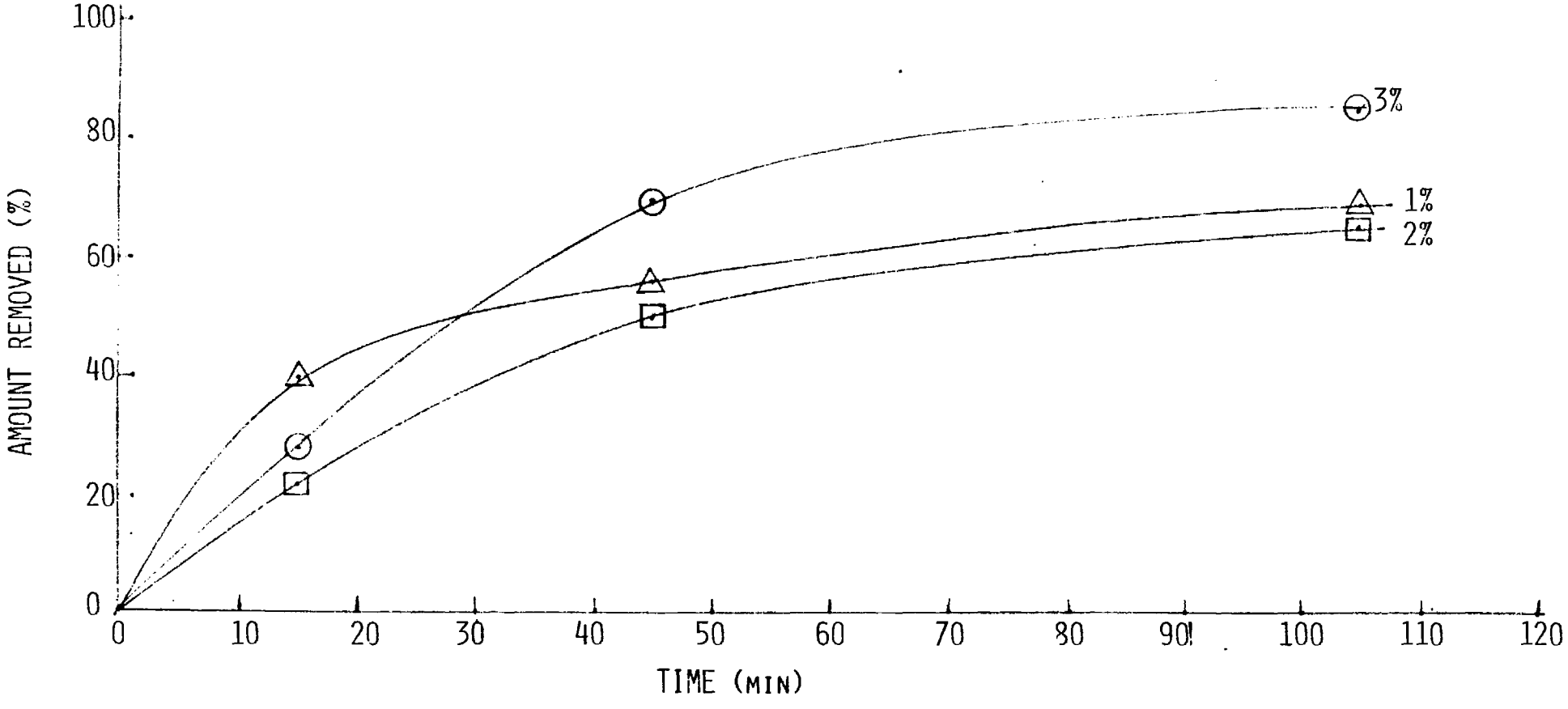


TABLE III

Amount of Stickies Removed from
1%, 2% and 3% Slurry Concentrations
at Various Times at Constant Stirring Velocity

Test Time (Min)	Slurry Concentration											
	1%				2%				3%			
	Plain		Spiral Wound		Plain		Spiral Wound		Plain		Spiral Wound	
	(gm)	(%)	(gm)	(%)	(gm)	(%)	(gm)	(%)	(gm)	(%)	(gm)	(%)
15	0.02	4	0.32	71	0.04	4	0.37	37	0.22	15	0.54	37
45	0.05	11	0.45	100	0.14	14	0.79	79	0.71	48	1.25	85
105	0.12	27	0.49	109	0.32	32	0.90	90	0.90	61	1.51	103

Figure 17 Percent Stickies Removed from 1%, 2%, and 3% Slurries
Time By Nine Plain Tubes at Constant Stirring Velocity

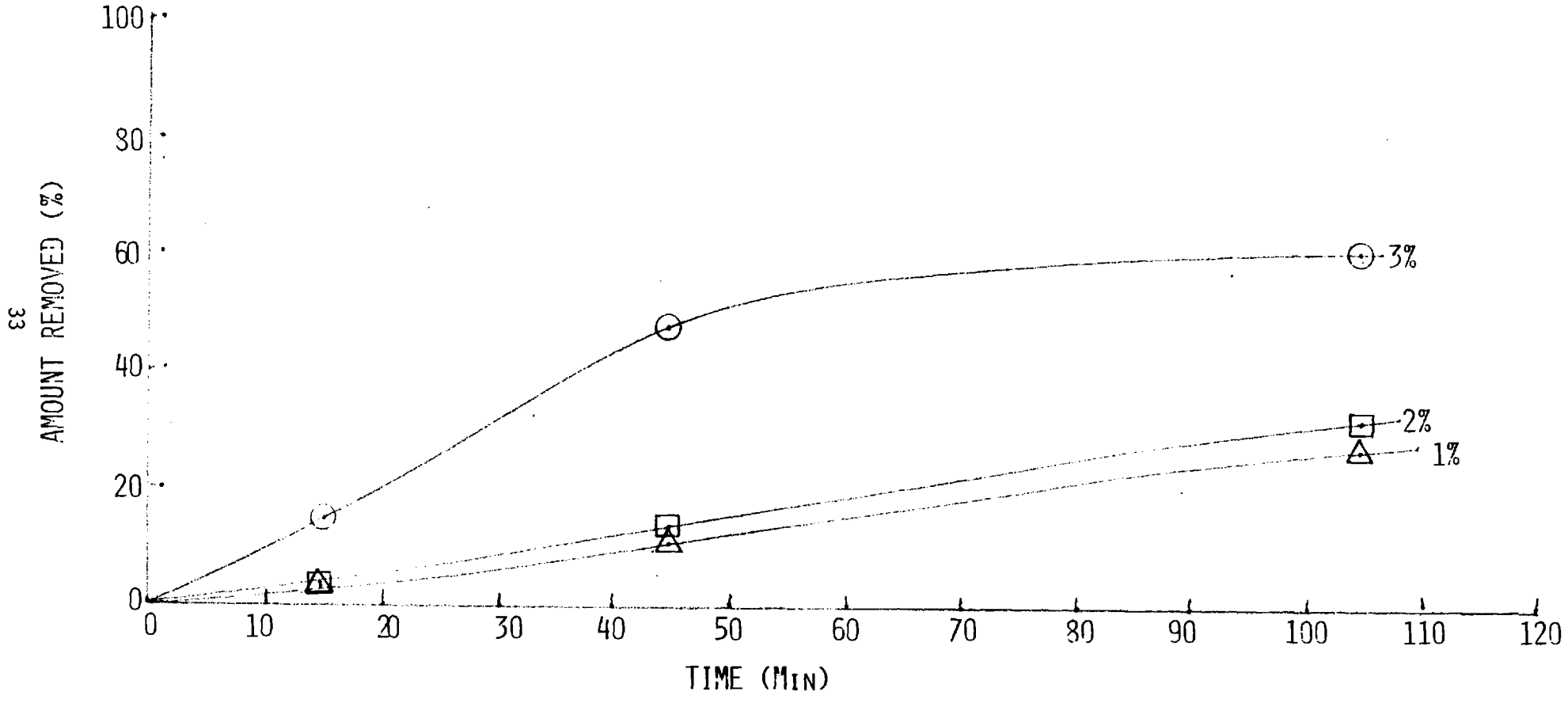
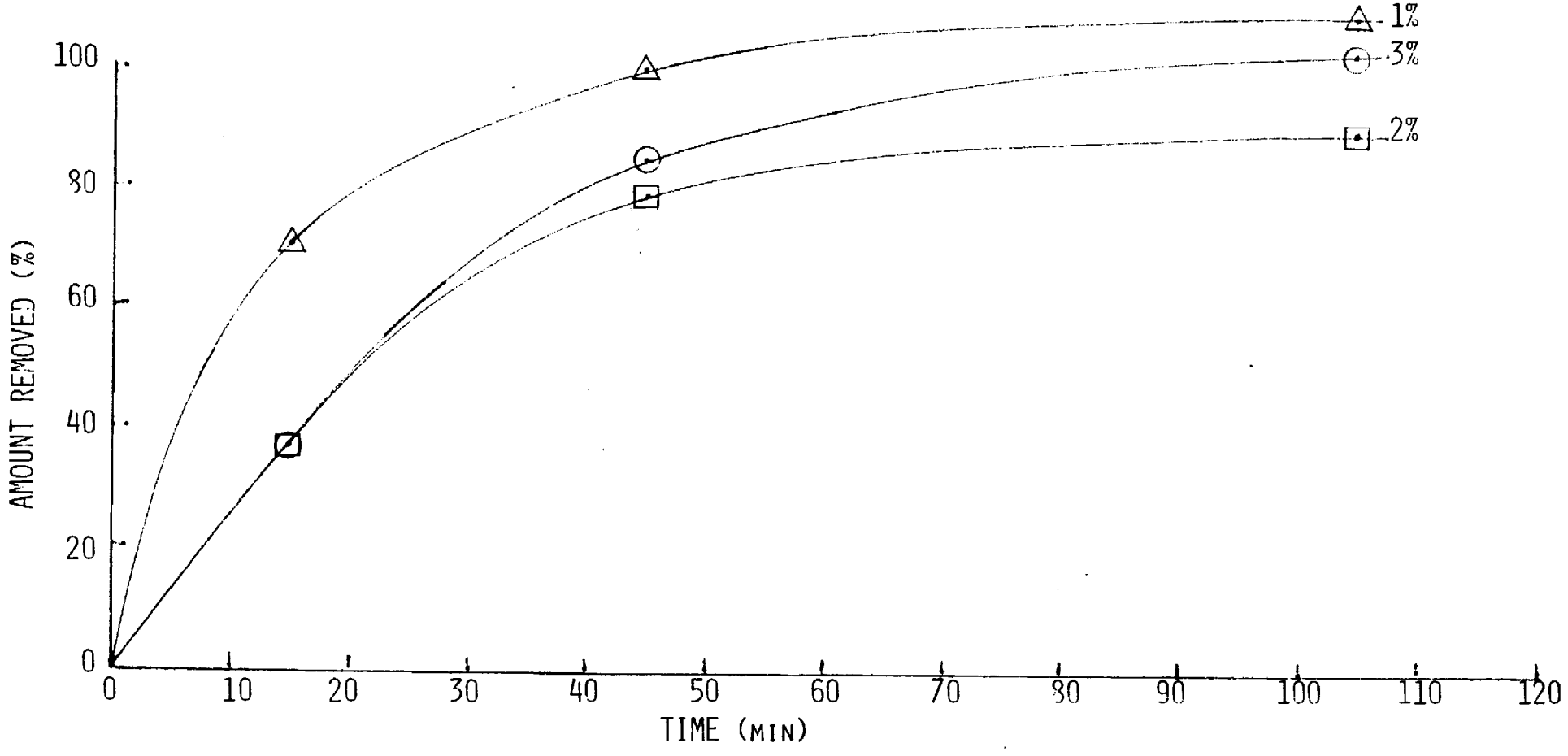


Figure 18 Percent Stickies Removed from 1%, 2% and 3% Slurries VS Time by Nine Spiral Wound Tubes at Constant Stirring Velocity



DISCUSSION

The most important result of all these experiments is that significant amounts of adhesive particle were captured and removed from slurries with consistencies from 1 to 3%. Also, the effects of stirring velocity are unambiguous in that the higher stirring speeds gave high removal percentages. This result is as might be expected since the higher stirring velocity is consistent with high probability of a sticky particle coming in contact with the scavenger.

The other results are not readily explained with the data which is available. It could be partially explained by experimental error. Since there is an insufficient amount of data to estimate this error there is no way to prove this hypothesis. Also, there may be smoe variation in the size of the sticky particles produced in the three different slurry consistencies. Again, without additional data this postulate cannot be substantiated.

RECOMMENDATIONS

Recommendations for future work are held in abeyance until Garden State has the opportunity to review this report. We anticipate a meeting with Garden State and Georgia Tech personnel to determine the continued course of action.